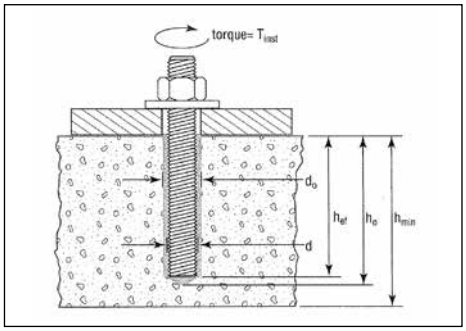
APPENDIX A: Strength Design Performance Values

SPECIFICATIONS AND DETAILS FOR INSTALLATION OF ANCHORS IN CONCRETE WITH EPCON G5 ADHESIVE

Characteristic	Symbol	Units	Threaded Rod Diameter (d)						
			3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Nominal carbide bit diameter	d_o	in.	7/16	9/16	3/4	7/8	1	1-1/8	1-3/8
Anchor embedment depth – minimum	$h_{ef,\,min}$	in.	1-5/8	2	2-1/2	3-1/2	3-1/2	4	5
Anchor embedment depth – maximum	$h_{ef,\,max}$	in.	3-3/8	4-1/2	5-5/8	6-3/4	7-7/8	9	11-1/4
Minimum spacing	s_{min}	in.	15/16	1	2-1/2	6	3-1/2	4	5
Minimum edge distance	c_{min}	in.	15/16	1	2-1/2	6	3-1/2	4	5
Minimum concrete thickness	h_{min}	in.	$h_{ef} + 1\text{-}1/4$		$h_{ef} + 2d_o$				
Maximum tightening torque for pretension clamping	T_{inst}	ft lb	9	16	47	90	145	170	370

For SI: 1 inch= 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356N-m, 1psi = .006895MPa

ANCHOR INSTALLATION



BRUSH SPECIFICATIONS

Brush color	Part #	(d) Anchor diameter (in.)	Minimum brush diameter (in.)
Grey	SB038	3/8	0.563
Brown	SB012	1/2	0.675
Green	SB058	5/8	0.900
Yellow	SB034	3/4	1.125
Red	SB078	7/8	1.350
Purple	SB010	1	1.463
Blue	SB125	1-1/4	1.575

For SI: 1 inch= 25.4mm ◆ Available with lead time.

WORKING TIMES AND CURE TIME FOR EPCON G5 ADHESIVE

Concrete Temp. (°F) [1,2]	Working Time (minutes) [3]	Cure Time (hours) [4]
70	15	24
90	9	24
110	9	24

For SI: t°(°F-32) X .555 = °C.

1 Adhesives must be installed in base material temperatures of 70°F to 110°F or artificially maintained.
2 Cartridge temperature should not differ significantly from the temperature of the base material.
3 Working time is the maximum time from the end of mixing to when the insertion of the anchor into the adhesive shall be completed.
4 Cure time is the minimum time from the end of working time to when the anchor may be torqued or loaded. Anchors are to be undisturbed during the cure time.

APPENDIX A: Strength Design Performance Values

TABLE 1: EPCON G5 ADHESIVE STEEL DESIGN INFORMATION FOR THREADED ROD

Characteristic		Symbol	Units	Anchor nominal diameter (d)						
				3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Threaded rod effective cross-sectional area		A_{se}	inch^2	0.078	0.142	0.226	0.335	0.462	0.606	0.969
Carbon Steel A36	Nominal steel strength in tension	N_{sa}	lb	4,500	8,230	13,110	19,400	26,780	35,130	56,210
	Nominal steel strength in shear	V_{sa}	lb	2,250	4,940	7,870	11,640	16,070	21,080	33,730
	Strength reduction factor for tension, steel failure mode[1]	Φ	–	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Strength reduction factor for shear, steel failure mode[1]	Φ	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Carbon Steel A193 B7	Nominal steel strength in tension	N_{sa}	lb	9,690	17,740	28,250	41,810	57,710	75,710	121,140
	Nominal steel strength in shear	V_{sa}	lb	4,845	10,640	16,950	25,090	34,630	45,430	72,680
	Strength reduction factor for tension, steel failure mode[1]	Φ	–	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Strength reduction factor for shear, steel failure mode[1]	Φ	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Stainless Steel F593	Nominal steel strength in tension	N_{sa}	lb	5,810	10,640	16,950	25,090	34,630	45,430	72,680
	Nominal steel strength in shear	V_{sa}	lb	2,905	6,390	10,170	15,050	20,780	27,260	43,610
	Strength reduction factor for tension, steel failure mode[1]	Φ	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength reduction factor for shear, steel failure mode[1]	Φ	–	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.70	0.70	0.70	0.70	0.70	0.70	0.70

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N

1 The tabulated value of Φ applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used as set forth in ACI 318 D.4.4. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5.

TABLE 2: EPCON G5 ADHESIVE CONCRETE BREAKOUT DESIGN INFORMATION

Characteristic	Symbol	Units	Nominal rod diameter, d (inch)						
			3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	–	24	24	24	24	24	24	24
Effectiveness factor for cracked concrete	$k_{c,cr}$	–	17	17	17	17	17	17	17
Minimum concrete thickness[2]	h_{min}	in.	h_{ef} + 1-1/4		$h_{ef} + 2d_o$				
Anchor embedment depth - minimum	$h_{ef,min}$	in.	1-5/8	2	2-1/2	3-1/2	3-1/2	4	5
Anchor embedment depth - maximum	$h_{ef,max}$	in.	3-3/8	4-1/2	5-5/8	6-3/4	7-7/8	9	11-1/4
Minimum spacing	s_{min}	in.	15/16	1	2-1/2	6	3-1/2	4	5
Minimum edge distance	c_{min}	in.	15/16	1	2-1/2	6	3-1/2	4	5
Critical edge distance	c_{ac}	in.	See Section 4.1.10 of the ESR-1137 Report						
Strength reduction factor for tension, concrete failure mode[1]	Φ	Cond B	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Strength reduction factor for shear, concrete failure mode[1]	Φ	Cond B.	0.70	0.70	0.70	0.70	0.70	0.70	0.70

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N

1 The tabulated value of Φ applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5 for Condition B.

2 d_o represents the nominal drill hole diameter.

TABLE 3: EPCON G5 ADHESIVE ANCHOR BOND STRENGTH DESIGN INFORMATION[1]

Characteristic		Symbol	Units	Nominal rod diameter (inch)						
				3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Anchor embedment depth - minimum		$h_{ef,min}$	in.	1-5/8	2	2-1/2	3-1/2	3-1/2	4	5
Anchor embedment depth - maximum		$h_{ef,max}$	in.	3-3/8	4-1/2	5-5/8	6-3/4	7-7/8	9	11-1/4
Temperature Range A[2,3,4]	Characteristic Bond Strength for Uncracked Concrete	$\tau_{K,uncr}$	psi	1,155	1,155	1,155	1,155	1,155	1,155	1,155
	Characteristic Bond Strength for Cracked Concrete[6]	$\tau_{K,cr}$	psi	475	560	560	560	560	560	560
Continuous Inspection	Strength Reduction Factor - Dry Concrete	$\Phi_{dry, ci}$	–	0.65	0.65	0.65	0.65	0.55	0.55	0.55
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat, ci}$	–	0.65	0.65	0.65	0.65	0.55	0.55	0.55
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf, ci}$	–	0.65	0.65	0.65	0.65	0.55	0.55	0.55
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub, ci}$	–	0.65	0.65	0.65	0.65	0.55	0.55	0.55
Periodic Inspection	Strength Reduction Factor - Dry Concrete	$\Phi_{dry, ci}$	–	0.55	0.55	0.55	0.55	0.45	0.45	0.45
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat, ci}$	–	0.55	0.55	0.55	0.55	0.45	0.45	0.45
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf, ci}$	–	0.55	0.55	0.55	0.55	0.45	0.45	0.45
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub, ci}$	–	0.55	0.55	0.55	0.55	0.45	0.45	0.45
Reduction factor for seismic tension		$\Phi_{N, seis}$	–	0.80						

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf= 1.356 N-m, 1 psi=0.006895 MPa.

1 Bond strength values correspond to concrete compressive strength range 2,500 psi to 8,500 psi.

2 Temperature range A: Maximum short term temperature of 130 degrees F and maximum long term temperature of 110 degrees F.

3 Short term elevated concrete temperatures are those that occur over brief interval, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

4 For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 36% for Temperature Range A

5 For structures assigned to IBC or IRC Seismic Design Category C, D, E, or F, or UBC Seismic Zone 2b, 3, or 4, bond strength values must be multiplied by $\alpha_{N,seis}$.

SEE TABLE ON ALLOWABLE STRESS DESIGN, ASD, USING LOW STRENGTH CARBON STEEL (A36) THREADED ROD ON NEXT PAGE.

TABLE 1: STEEL DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD [(1)]

Characteristic		Symbol	Units	Anchor nominal diameter (d)						
				3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Threaded rod effective cross-sectional area		A_{se}	inch^2	0.078	0.142	0.226	0.335	0.462	0.606	0.969
Carbon Steel A36	Nominal steel strength in tension	N_{sa}	lb	4,500	8,230	13,110	19,400	26,780	35,130	56,210
	Nominal steel strength in shear	V_{sa}	lb	2,250	4,940	7,870	11,640	16,070	21,080	33,730
	Strength reduction factor for tension, steel failure mode[1]	Φ	–	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Strength reduction factor for shear, steel failure mode[1]	Φ	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Carbon Steel A193 B7	Nominal steel strength in tension	N_{sa}	lb	9,690	17,740	28,250	41,810	57,710	75,710	121,140
	Nominal steel strength in shear	V_{sa}	lb	5,810	10,640	16,950	25,090	34,630	45,430	72,680
	Strength reduction factor for tension, steel failure mode[1]	Φ	–	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Strength reduction factor for shear, steel failure mode[1]	Φ	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Stainless Steel F593	F593 CW1 Nominal steel strength in tension	N_{sa}	lb	7.365	13,480	21,470	-	-	-	-
	F593 CW1 Nominal steel strength in shear	V_{sa}	lb	3,680	6,740	10,735	-	-	-	-
	F593 CW2 Nominal steel strength in tension	N_{sa}	lb	-	-	-	25,385	35,110	46,055	73,645
	F593 CW2 Nominal steel strength in shear	V_{sa}	lb	-	-	-	12,690	17,555	23,030	36,820
	Strength reduction factor for tension, steel failure mode[1]	Φ	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength reduction factor for shear, steel failure mode[1]	Φ	–	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.70	0.70	0.70	0.70	0.70	0.70	0.70

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356 N-M, 1 pso = 0.006895 MPa.

1 The tabulated value of Φ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI-11 9.2 are used. If load combinations of ACI 318-11 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.

TABLE 2: CONCRETE BREAKOUT DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD [(1)]

Characteristic	Symbol	Units	Nominal rod diameter, d (inch)						
			3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Effectiveness factor for uncracked concrete	$k_{c,uncr}$	–	24	24	24	24	24	24	24
Effectiveness factor for cracked concrete	$k_{c,cr}$	–	17	17	17	17	17	17	17
Minimum concrete thickness	h_{min}	in.	h_{ef} + 1-1/4		$h_{ef} + 2d_o$				
Anchor embedment depth - minimum	$h_{ef,min}$	in.	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	5
Minimum spacing	s_{min}	in.	15/16	1-1/2	2-1/2	3	3-1/2	4	5
Minimum edge distance	c_{min}	in.	15/16	1-1/2	2-1/2	3	3-1/2	4	5
Critical edge distance	c_{ac}	in.	See Section 4.1.10 of this report						
Strength reduction factor for tension, concrete failure mode[1]	Φ	Cond B	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Strength reduction factor for shear, concrete failure mode[1]	Φ	Cond B.	0.70	0.70	0.70	0.70	0.70	0.70	0.70

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356 N-M, 1 pso = 0.006895 MPa.

1 The tabulated value of Φ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2 are used and the requirements of ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, for Condition B are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4 for Condition B.

TABLE 3: RED HEAD A7+ ADHESIVE ANCHOR BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT THREADED ROD[1,5]

Characteristic		Symbol	Units	Nominal rod diameter (inch)						
				3/8″	1/2″	5/8″	3/4″	7/8″	1″	1-1/4″
Anchor embedment depth - minimum		$h_{ef,min}$	in.	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	5
Anchor embedment depth - maximum		$h_{ef,max}$	in.	7-1/2	10	12-1/2	15	17-1/2	20	25
Temperature Range A[2]	Characteristic Bond Strength for Uncracked Concrete	$\tau_{K,uncr}$	psi	1,770	1,770	1,770	1,770	1,490	1,490	1,490
	Characteristic Bond Strength for Cracked Concrete	$\tau_{K,cr}$	psi	1,060	790	860	890	695	655	585
Temperature Range B[3,4]	Characteristic Bond Strength for UNCracked Concrete	$\tau_{K,uncr}$	psi	1,275	1,275	1,275	1,275	1,080	1,080	1,080
	Characteristic Bond Strength for Cracked Concrete	$\tau_{K,cr}$	psi	765	570	620	640	500	475	420
Continuous Inspection	Strength Reduction Factor - Dry Concrete	$\Phi_{dry, ci}$	–	0.65	0.65	0.65	0.65	0.55	0.55	0.55
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat, ci}$	–	0.65	0.65	0.65	0.65	0.55	0.55	0.55
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub, ci}$	–	0.65	0.55	0.55	0.65	0.65	0.55	0.65
Periodic Inspection	Strength Reduction Factor - Dry Concrete	$\Phi_{dry, ci}$	–	0.55	0.55	0.55	0.55	0.55	0.55	0.55
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub, ci}$	–	0.65	0.45	0.45	0.65	0.55	0.45	0.65
Reduction factor for seismic tension		$\Phi_{N, seis}$	–	0.89	0.75	0.76	0.66	0.77	0.80	0.80

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf= 1.356 N-m, 1 psi=0.006895 MPa.

1Bond strength values correspond to concrete compressive strengths ranging from 2,500 psi to 8,000 psi [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

2Temperature range A: Maximum short term temperature of 130°F and maximum long term temperature of 110°F.

3Temperature range B: Maximum short term temperature of 176°F and maximum long term temperature of 110°F.

4For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 4% for Temperature Range B.

5For structures assigned to IBC or IRC Seismic Design Category C, D, E, or F, bond strength values must be multiplied by αN,seis.

TABLE 4: STEEL DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS[1]

Characteristic		Symbol	Units	Nominal rod diameter (inch)							
				No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Nominal bar diameter		d	in.	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4
Reinforcing bar effective cross-sectional area		Ase	in.[2]	0.11	0.2	0.31	0.44	0.6	0.79	1.00	1.27
ASTM 615 Grade 60	Nominal steel strength in tension	N_{sa}	lb	9,900	18,000	27,900	39,600	54,000	71,100	90,000	114,300
	Nominal steel strength in shear	V_{sa}	il	5,940	10,800	16,740	23,760	32,400	42,660	54,000	68,580
	Strength reduction factor for tension, steel failure mode	Φ	-	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength reduction factor for shear, steel failure mode[1]	Φ	-	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Reduction factor for seismic shear	$\alpha_{v,seis}$	–	0.91	0.91	0.91	0.90	0.90	0.75	0.75	0.75

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf= 1.356 N-m, 1 psi=0.006895 MPa.

1 The tabulated value of φ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2 are used. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of φ must be determined in accordance with ACI 318-11 D.4.4.

TABLE 5: CONCRETE BREAKOUT DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING BARS (1,2)

Characteristic	Symbol	Units	Nominal rod diameter (inch)							
			No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Effectiveness factor for uncracked concrete	k_{uncr}	-	24	24	24	24	24	24	24	24
Effectiveness factor for cracked concrete	k_{cr}	-	17	17	17	17	17	17	17	17
Minimum concrete thickness Nominal steel strength in tension	h_{min}	in.	hef + 1-1/4		-	hef + 2do				
Anchor embedment depth - minimum	$h_{ef,min}$	in.	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	4-1/2	5
Minimum Spacing	s_{min}	in.	15/16	1-1/2	2-1/2	3	3-1/2	4	4-1/2	5
Minimum edge distance	c_{min}	in.	15/16	1-1/2	2-1/2	3	3-1/2	4	4-1/2	5
Critical edge distance	c_{ac}	in.		See section 4.1.10 of this report						
Strength reduction factor for tension, concrete failure mode[1]	ϕ	Cond. B	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Strength reduction factor for shear, concrete failure mode [1]	ϕ	Cond. B	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf= 1.356 N-m, 1 psi=0.006895 MPa.

1 The tabulated value of φ applies when the load combinations of Section 1605.2 of the IBC, ACI 318-14 5.3 or ACI 318-11 9.2 are used and the requirements of ACI 318-14 17.3.3 or ACI 318-11 D.4.3, as applicable, for Condition B are met. If the load combinations of ACI 318-11 Appendix C are used, the appropriate value of φ must be determined in accordance with ACI 318-11 D.4.4 for Condition B.

2 The value of f'c used for calculation must be limited to maximum 8,000 psi (55 MPa) in accordance with ACI 318-14 17.2.7 or ACI 318-11 D.3.7, as applicable

TABLE 6: RED HEAD A7+ ADHESIVE ANCHOR BOND STRENGTH DESIGN INFORMATION FOR U.S. CUSTOMARY UNIT REINFORCING STEEL (1,5)

Characteristic		Symbol	Units	Nominal rod diameter (inch)							
				No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Anchor embedment depth - minimum		h_{ef}	in.	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	4-1/2	5
Anchor embedment depth - maximum		h_{ef}	in.	7-1/2	10	12-1/2	15	17-1/2	20	22-1/2	25
Temperature Range A[2]	Characteristic Bond Strength for Uncracked Concrete	$\tau_{\kappa,uncr}$	psi	1,675	1,935	1,900	1,700	1,635	1,615	1,585	1,550
	Characteristic Bond Strength for Cracked Concrete[6]	$\tau_{\kappa,cr}$	psi	755	755	755	585	585	585	585	585
Temperature Range B[3,4]	Characteristic Bond Strength for Uncracked Concrete	$\tau_{\kappa,uncr}$	psi	1,210	1,400	1,370	1,230	1,180	1,165	1,145	1,120
	Characteristic Bond Strength for Cracked Concrete[6]	$\tau_{\kappa,cr}$	psi	545	545	545	420	420	420	420	435
Continuous Inspection	Strength Reduction Factor - Dry Concrete	$\Phi_{dry, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub, ci}$	–	0.65	0.55	0.55	0.65	0.65	0.55	0.55	0.55
Periodic Inspection	Strength Reduction Factor - Dry Concrete	$\Phi_{dry, ci}$	–	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.65
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf, ci}$	–	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub, ci}$	–	0.65	0.45	0.45	0.65	0.55	0.45	0.45	0.65
Reduction factor for seismic tension		$\Phi_{N, seis}$	–	0.92	0.92	0.92	0.82	0.82	0.82	0.82	0.82

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356 N-M, 1 psi = 0.006895 MPa.

1Bond strength values correspond to concrete compressive strengths ranging from 2,500 psi to 8,000 psi [minimum of 24 MPa is required under ADIBC Appendix L, Section 5.1.1].

2Temperature range A: Maximum short term temperature of 130°F and maximum long term temperature of 110°F.

3Temperature range B: Maximum short term temperature of 176°F and maximum long term temperature of 110°F.

4For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 4% for Temperature Range B.

5For structures assigned to IBC or IRC Seismic Design Category C, D, E, or F, bond strength values must be multiplied by αN,seis.

TABLE 7: EXAMPLE RED HEAD A7+ ADHESIVE ALLOWABLE STRESS DESIGN VALUES (ASD) FOR ILLUSTRATIVE PURPOSES

Anchor Diameter (d)	Embedment Depth, h_{ef} (in) (min./max)	* Characteristic Bond Strength $\tau_{K,uncr}$ (psi)	Allowable Tension Load LBS	Controlling Failure Mode
			2,500 PSI- 8000 PSI	
3/8	2-3/8	1,770	1,929	Concrete
	7-1/2		2,280	Steel
1/2	2-3/4	1,770	2,403	Concrete
	10		4,171	Steel
5/8	3-1/8	1,770	2,911	Concrete
	12-1/2		6,644	Steel
3/4	3-1/2	1,770	3,451	Concrete
	15		9,831	Steel
7/8	3-1/2	1,490	3,451	Concrete
	17-1/2		13,571	Steel
1	4	1,490	4,216	Concrete
	20		17,802	Steel
1-1/4	5	1,490	5,892	Concrete
	25		28,485	Steel

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356 N-M, 1 psi = 0.006895 MPa.

This table was developed based on the following conditions:

1Single anchor with static tension only, A36 threaded rod

2Vertical downward installation direction

3Inspection regimen = Periodic

4Installation temperature = 30°F to 90°F

5Long term temperature = 110°F

6Short term temperature = 130°F

7Dry hole condition (carbide drilled hole)

8Embedment = hef (min/max for each diameter)

9Concrete determined to remain uncracked for the life of the anchorage

10Load combinations from ACI 318-11 Section 9.2 (no seismic loading)

1130% dead load and 70% live load, controlling load combination 1.2D + 1.6L

12Calculation of weighted average for α = 0.3*1.2 + 0.7*1.6 = 1.48

13f' c = 2,500 psi (normal weight concrete)

14ca1 = ca2 ≥ cac

15h ≥ hmin

APPENDIX A: Strength Design Performance Values

TABLE 4: STRENGTH DESIGN USING LOW STRENGTH CARBON STEEL (A36) THREADED ROD ◆ INSTALLED IN f′c = 2,500 PSI – 8,000 PSI UNCRACKED CONCRETE WITH EPCON G5 ADHESIVE

Anchor Diameter (d)	Embedment Depth, hef (in) (min./max)	* Characteristic Bond Strength τ_K, uncr (psi)	Allowable Tension Load LBS				
			2,500 PSI (Controlling Mode)	3,000 PSI (Controlling Mode)	4,000 PSI (Controlling Mode)	6,000 PSI (Controlling Mode)	8,000 PSI (Controlling Mode)
3/8	2-3/8	1,155	1,777 (BOND)	1,777 (BOND)	1,777 (BOND)	1,777 (BOND)	1,777 (BOND)
	3-3/8	1,155	2,525 (BOND)	2,525 (BOND)	2,525 (BOND)	2,525 (BOND)	2,525 (BOND)
1/2	2-3/4	1,155	2,743 (BOND)	2,743 (BOND)	2,743 (BOND)	2,743 (BOND)	2,743 (BOND)
	4-1/2	1,155	4,488 (BOND)	4,488 (BOND)	4,488 (BOND)	4,488 (BOND)	4,488 (BOND)
5/8	3-1/8	1,155	3,896 (BOND)	3,896 (BOND)	3,896 (BOND)	3,896 (BOND)	3,896 (BOND)
	5-5/8	1,155	7,013 (BOND)	7,013 (BOND)	7,013 (BOND)	7,013 (BOND)	7,013 (BOND)
3/4	3-1/2	1,155	5,107 (CONCRETE)	5,236 (BOND)	5,236 (BOND)	5,236 (BOND)	5,236 (BOND)
	6-3/4	1,155	10,098 (BOND)	10,098 (BOND)	10,098 (BOND)	10,098 (BOND)	10,098 (BOND)
7/8	3-1/2	1,155	4,998 (BOND)	4,998 (BOND)	4,998 (BOND)	4,998 (BOND)	4,998 (BOND)
	7-7/8	1,155	11,246 (BOND)	11,246 (BOND)	11,246 (BOND)	11,246 (BOND)	11,246 (BOND)
1	4	1,155	6,240 (CONCRETE)	6,528 (BOND)	6,528 (BOND)	6,528 (BOND)	6,528 (BOND)
	9	1,155	14,668 (BOND)	14,668 (BOND)	14,668 (BOND)	14,668 (BOND)	14,668 (BOND)
1-1/4	5	1,155	8,721 (CONCRETE)	9,553 (CONCRETE)	10,200 (BOND)	10,200 (BOND)	10,200 (BOND)
	11-1/4	1,155	22,950 (BOND)	22,950 (BOND)	22,950 (BOND)	22,950 (BOND)	22,950 (BOND)

For SI: 1 inch= 25.4mm, 1 lbf = 4.45N, 1ft-lbf= 1.356 N-M, 1 psi=0.006895 MPa

1. Refer to Tables 1, 2 and 3 for steel, concrete and bond strength design information.
2. Bond strength reduction factors based on periodic inspection and dry, saturated, water-filled or submerged concrete conditions.

◆ Call 800-848-5611 for controlling modes and loads using stainless steel or higher strength threaded rod.

Procedure to calculate tension load for strength design – SD

Example: 1/2" diameter anchor with embedment depth of 4-1/2" installed in 4,000 psi concrete

1. Calculate steel strength – tension (per ACI 318 D.5.1.2)
   $\Phi N_{sa} = 0.75 * 8,230 =$ 6,173 lbs
2. Calculate concrete breakout strength – tension
   $\Phi k_{uncr}\sqrt{2,500\ psi}\ h_{ef}^{1.5} = 0.65 * 24 * \sqrt{2,500} * 4\text{-}1/2^{1.5}$
   = 7,446 lbs per ACI 318 D.5.2
   Normalize load for 4,000 psi concrete $= 7,446\sqrt{\frac{4,000}{2,500}} =$ 9,418 lbs
3. Calculate bond strength – tension
   $\Phi * d * \pi * h_{ef} * \tau_{k,uncr} = 0.55 * 1/2 * \pi * 4\text{-}1/2 * 1,155 =$ 4,488 lbs (per equations D-16a, and D-16f of ESR-1137)
4. Controlling strength is 4,488 lbs (bond) – lowest load value amongst bond, concrete and steel controlling modes

Strength Design Load = 4,488 lbs

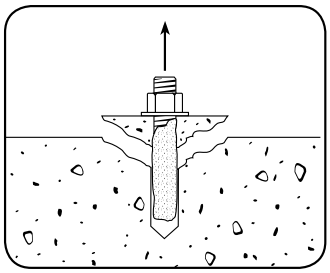
Procedure to calculate tension load for allowable stress design – ASD

1. Determine load combination and conversion factor.
   – Assume 30% dead load and 70% live load using load combination = 1.2D + 1.6L = 1.2 (0.3) + 1.6 (0.7) = 1.48 (per ACI318 Sect. 9.2)
2. Divide controlling strength (see strength design procedure - step 4) 4,488 lbs by the conversion factor of 1.48 = 4,488/1.48 =3,032 lbs (steel)

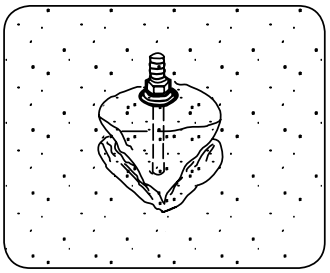
Allowable Strength Design Load = 3,032 lbs

Controlling Modes

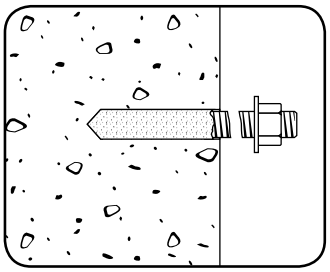
Bond



Concrete



Steel



APPENDIX B: Strength Design Performance values in accordance to 2015 IBC

ITW RED HEAD TRUBOLT WEDGE ANCHOR

DESIGN INFORMATION TESTED TO ICC-ES AC193 AND ACI 355.2, IN ACCORDANCE WITH 2015 IBC

Trubolt® Wedge Anchors

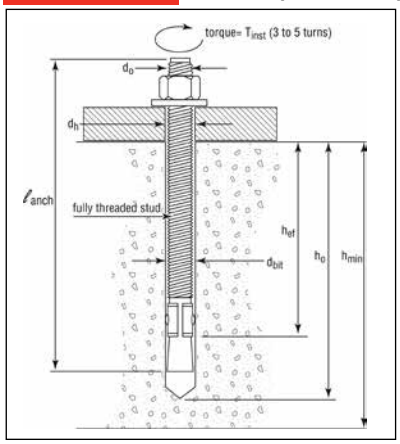
TRUBOLT WEDGE ANCHOR DESIGN INFORMATION[1,2,3]

DESIGN INFORMATION	Symbol	Units	Nominal Anchor Diameter									
			1/4		3/8		1/2		5/8		3/4	
Anchor O.D.	d_o	in	0.250		0.375		0.500		0.625		0.750	
Effective embedment	h_{ef}	in	1-1/2	2	1-3/4	2-5/8	1-7/8	3-3/8	2-1/2	4	3-1/2	4-3/4
Minimum member thickness	h_{min}	in	4	4	4	5	5	6	5	8	6	8
Critical edge distance	c_{ac}	in	2-5/8	3	2-5/8	5-1/4	3-3/4	6-3/4	5	8	7	9
Minimum edge distance	c_{min}	in	1-3/4	1-1/2	2-1/4	2	3-3/4	3-3/4	4-1/4	3-1/4	3-3/4	3-1/2
Minimum anchor spacing	s_{min}	in	1-3/4	1-1/2	2-1/4	2	3-3/4	3-3/4	4-1/4	3-1/4	3-3/4	3-1/2
Min. Specified Yield Strength	f_y	lb/in^2	55,000									
Min. Specified Ultimate Strength	f_{uta}	lb/in^2	75,000									
Effective tensile stress area	A_{se}	in^2	0.032		0.078		0.142		0.226		0.334	
Steel strength in tension	N_s	lb	2,385		5,815		10,645		16,950		25,050	
Steel strength in shear	V_s	lb	1,430		2,975	3,490	4,450	6,385	6,045	10,170	10,990	15,030
Pullout strength, uncracked concrete	$N_{p,uncr}$	lb	1,392	1,706	2,198	3,469	2,400	4,168	4,155	6,638	8,031	10,561
Anchor Category (All anchors are ductile)			1									
Effectiveness factor k_{uncr} uncracked concrete			24									
Axial stiffness in service load range	β	lb/in	14,651	9,385	17,515	26,424	32,483	26,136	42,899	21,749	43,576	28,697
Coefficient for variation for axial stiffness in service load range			34	47	28	45	17	33	55	22	63	28
Strength reduction factor ϕ for tension, steel failure modes			0.75									
Strength reduction factor ϕ for shear, steel failure modes			0.65									
Strength reduction factor ϕ for tension, concrete failure modes, Condition B			0.65									
Strength reduction factor ϕ for shear, concrete failure modes, Condition B			0.70									

[1] Trubolt+ Anchor Design Strengths must be determined in accordance with ACI 318-05 Appendix D and this table
[2] The Trubolt+ Wedge Anchor is a ductile steel element as defined by ACI 318 D.1
[3] 1/4", 3/8", & 1/2" diameter data is listed in ICC-ES ESR-2251.

Trubolt® Wedge Anchors

TRUBOLT WEDGE ANCHOR (INSTALLED)



TRUBOLT WEDGE INSTALLATION INFORMATION

	Symbol	Units	Nominal Anchor Diameter (in.)									
			1/4		3/8		1/2		5/8		3/4	
Anchor outer diameter	d_o	in	0.25		0.375		0.5		0.625		0.750	
Nominal carbide bit diameter	d_{bit}	in	1/4		3/8		1/2		5/8		3/4	
Effective embedment depth	h_{ef}	in	1-1/2	2	1-3/4	2-5/8	1-7/8	3-3/8	2-1/2	4	3-1/2	4-3/4
Min hole depth	h_o	in	2	2-1/2	2-1/2	3-3/8	2-3/4	4-1/4	3-3/4	5-1/4	4-3/4	6
Min slab thickness	h_{min}	in	4		4	5	5	6	5	8	6	8
Installation torque	T_{inst}	ft-lb	4		25		55		90		110	
Min hole diameter in fixture	d_h	in	5/16		7/16		9/16		11/16		13/16	

APPENDIX B: Strength Design Performance values in accordance to 2015 IBC

Trubolt®
Wedge Anchors

TRUBOLT WEDGE PULLOUT STRENGTH ($N_{p, unc}$) (POUNDS) [1]

Nominal Anchor Diameter (in.)	Effective Embedment Depth (in.)	Concrete Compressive Strength			
		f'c = 2,500 psi	f'c = 3,000 psi	f'c = 4,000 psi	f'c = 6,500 psi
1/4	1-1/2	1,392	1,525	1,610	1,822
	2	1,706	1,869	1,947	2,151
3/8	1-3/4	2,198	2,408	2,621	3,153
	2-5/8	3,469	3,800	3,936	4,275
1/2	1-7/8	2,400	2,629	3,172	4,520
	3-3/8	4,168	4,520	4,520	4,520
5/8	2-1/2	4,155	4,155	4,376	5,578
	4	6,638	6,900	7,968	10,157
3/4	3-1/2	8,031	8,322	9,610	12,251
	4-3/4	10,561	10,561	10,561	12,251

For SI: 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 Mpa
1 Values are for single anchors with no edge distance or spacing reduction.

TRUBOLT WEDGE ANCHOR ALLOWABLE STATIC TENSION (ASD), NORMAL-WEIGHT UNCRACKED CONCRETE [1-6]

Nominal Anchor Diameter (in.)	Effective Embedment Depth (in.)	Concrete Compressive Strength			
		f'c = 2,500 psi	f'c = 3,000 psi	f'c = 4,000 psi	f'c = 6,500 psi
1/4	1-1/2	611	670	707	800
	2	749	821	855	945
3/8	1-3/4	965	1,058	1,151	1,385
	2-5/8	1,524	1,669	1,729	1,878
1/2	1-7/8	1,054	1,155	1,393	1,985
	3-3/8	1,831	1,985	1,985	1,985
5/8	2-1/2	1,825	1,825	1,922	2,450
	4	2,915	3,030	3,499	4,461
3/4	3-1/2	3,527	3,655	4,221	5,381
	4-3/4	4,638	4,638	4,638	5,381

For SI: 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 Mpa
Design Assumptions:
1 Single anchor with static tension load only.
2 Concrete determined to remain uncracked for the life of the anchorage.
3 Load combinations from 2006 IBC, Sections 1605.2.1 and 1605.3.1 (no seismic loading).
4 Thirty percent dead load and 70 percent live load, controlling load combination 1.2D + 1.6L
5 Calculation of weighted average: 1.2D + 1.6L = 1.2 (0.3) + 1.6 (0.7) = 1.48
6 Values do not include edge distance or spacing reductions.

TRUBOLT WEDGE ANCHOR ALLOWABLE STATIC SHEAR (ASD), STEEL (POUNDS)[1-5]

Nominal Anchor Diameter (in.)	Effective Embedment Depth (in.)	Allowable Steel Capacity, Static Shear
1/4	1-1/2	628
	2	
3/8	1-3/4	1,307
	2-5/8	1,533
1/2	1-7/8	1,954
	3-3/8	2,804
5/8	2-1/2	2,655
	4	4,467
3/4	3-1/2	4,827
	4-3/4	6,601

For SI: 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 Mpa
Design Assumptions:
1 Single anchor with static shear load only.
3 Load combinations from 2006 IBC, Sections 1605.2.1 and 1605.3.1 (no seismic loading).
3 Thirty percent dead load and 70 percent live load, controlling load combination 1.2D + 1.6L
4 Calculation of weighted average: 1.2D + 1.6L = 1.2 (0.3) + 1.6 (0.7) = 1.48
5 Values do not include edge distance or spacing reductions.

APPENDIX C: Strength Design Performance values in accordance with 2015 IBC

ITW RED HEAD TRUBOLT+ and OVERHEAD TRUBOLT+ EDGE ANCHOR DESIGN INFORMATION TESTED TO ICC-ES AC 193 AND ACI 355.2, IN ACCORDANCE WITH 2015 IBC

TRUBOLT+ AND OVERHEAD TRUBOLT+ WEDGE ANCHOR DESIGN INFORMATION[1]

Trubolt+ Seismic Wedge Anchors

Characteristic	Symbol	Units	Nominal Anchor Diameter (inch)[4]									
			3/8"		1/2"				5/8"		3/4"	
Anchor category	1, 2 or 3	—	1		1				1		1	
Minimum effective embedment depth	h_{ef}	in	1-5/8		2		3-1/4		2-3/4	4-1/4	3-3/4	
Minimum concrete member thickness	h_{min}	in	4	5	4	6	6	8	6	6-1/4	7	8
Critical edge distance	c_{ac}	in	5	3	6	6	7-1/2	6	7-1/2	6-1/2	12	10
Data for Steel Strengths – Tension and Shear												
Minimum specified yield strength	f_y	psi	60,000		55,000				55,000		55,000	
Minimum specified ultimate strength	f_{uta}	psi	75,000		75,000				75,000		75,000	
Effective tensile stress area (neck)	A_{se}	in^2	0.056		0.119				0.183		0.266	
Effective tensile stress area (thread)	A_{se}	in^2	0.075		0.142				0.217		0.332	
Steel strength in tension	N_{sa}	lbf	4,200		8,925				13,725		19,950	
Steel strength in shear, uncracked or cracked concrete [6]	V_{sa}	lbf	1,830		5,175				8,955		14,970	
Steel strength in shear – seismic loads	V_{eq}	lbf	1,545		5,175				8,955		11,775	
Strength reduction factor f for tension, steel failure modes [2]			0.75		0.75				0.75		0.75	
Strength reduction factor f for shear, steel failure modes [2]			0.60		0.65				0.65		0.65	
Data for Concrete Breakout Concrete Pryout Strengths in Tension and Shear												
Effectiveness factor – uncracked concrete	k_{uncr}	—	24		24				24		24	
Effectiveness factor – cracked concrete	k_{cr}	—	17		17				17		17	
Modification factor for cracked and uncracked concrete [3]	$\Psi_{c,N}$	—	1.0		1.0				1.0		1.0	
Coefficient for pryout strength	k_{cp}	—	1.0		1.0		2.0		2.0		2.0	
Load-bearing length of anchor	l_e	in	1.625		2.0		3.25		2.75	4.25	3.75	
Strength reduction factor ϕ for tension, concrete failure modes, Condition B [2]			0.65		0.65				0.65		0.65	
Strength reduction factor ϕ for shear, concrete failure modes, Condition B [2]			0.70		0.70				0.70		0.70	
Data for Pullout Strengths												
Pullout strength, uncracked concrete	$N_{p,uncr}$	lbf	See Footnote [5]		See Footnote [5]		6,540		5,430	8,900	See Footnote [5]	
Pullout strength, cracked concrete	$N_{p,cr}$	lbf	See Footnote [5]		See Footnote [5]				See Footnote [5]		See Footnote [5]	
Pullout strength for seismic loads	N_{eq}	lbf	See Footnote [5]		See Footnote [5]				See Footnote [5]	6,715	See Footnote [5]	
Strength reduction factor f for tension, pullout failure modes, Condition B [2]			See Footnote [5]		0.65				0.65		See Footnote [5]	
Additional Anchor Data												
Axial stiffness in service load range in uncracked concrete	b_{uncr}	lbf/in	100,000		250,000				250,000		250,000	
Axial stiffness in service load range in cracked concrete	b_{cr}	lbf/in	40,000		20,000				20,000		20,000	

For SI: 1 inch = 25.4 mm, 1 in2 = 645.16mm2, 1 lbf = 4.45 N, 1 psi = 0.006895 MPa, 1 lbf • 102/in - 17,500 N/m.

[1] The 1/2", 5/8" and 3/4" diameter Trubolt+ Wedge Anchors are ductile steel elements as defined by ACI 318 D.1. The 3/8" diameter Trubolt+ is considered ductile under tension loading and brittle under shear loading.

[2] All values of ϕ apply to the load combinations of IBC Section 1605.2, ACI 318 Section 9.2 or UBC Section 1612.2. If the load combinations of Appendix C or UBC Section 1909.2 are used, the appropriate value of ϕ must be determined in accordance with ACI 318 D.4.5. For installations where reinforcement that complies with ACI 318 Appendix D requirements for Condition A is present, the appropriate ϕ factor must be determined in accordance with ACI 318 D.4.4.

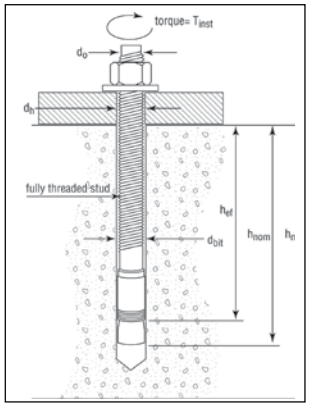
[3] For all design cases $\Psi_{c,N} = 1.0$. The appropriate effectiveness factor for cracked concrete (k_{cr}) or uncracked concrete (k_{uncr}) must be used.

[4] The actual diameter for the 3/8" diameter anchor is 0.361" for the 5/8" diameter anchor is 0.615" and the 3/4" diameter anchor is 0.7482".

[5] Anchor pullout strength does not control anchor design. Determine steel and concrete capacity only.

[6] Steel strength in shear values are based on test results per ACI 355.2, Section 9.4 and must be used for design.

TRUBOLT+ WEDGE ANCHOR (INSTALLED)



TRUBOLT+ AND OVERHEAD TRUBOLT+ WEDGE INSTALLATION INFORMATION

Parameter	Notation	Units	Nominal Achor Diameter (inch)									
			3/8		1/2				5/8		3/4	
Anchor outer diameter	d_o	inches	0.361		0.5				0.615		0.7482	
Nominal carbide bit diameter	d_{bit}	inches	3/8		1/2				5/8		3/4	
Effective embedment depth	h_{ef}	inches	1-5/8		2		3-1/4		2-3/4	4-1/4	3-3/4	
Minimum anchor embedment depth	h_{nom}	inches	2		2-1/2		3-3/4		3-1/4	4-3/4	4-3/8	
Minimum hole depth[1]	h_o	inches	2-1/4		2-3/4		4		3-1/2	5	4-5/8	
Minimum concrete member thickness[1]	h_{min}	inches	4	5	4	6	6	8	6	6-1/4	7	8
Critical edge distance[1]	c_{ac}	In.	5	3	6	6	7-1/2	6	7-1/2	6-1/2	12	10
Minimum anchor spacing[1]	s_{min}	In.	3-1/2	2-1/2	6	5-3/4	4	5-3/4	8	6	6	6
Minimum edge distance[1]	c_{min}	In.	3		6				7-1/2	5	7-1/2	7-1/2
Minimum overall anchor length	l	inches	2-1/2		3-3/4		4-1/2		4-1/4	6	5-1/2	
Installation torque	T_{inst}	ft-lb	30		45				90		110	
Minimum diameter of hole in fastened part	d_h	inches	1/2		5/8				3/4		7/8	

For SI: 1 inch = 25.4 mm, 1 ft-lb = 1.356 N-m.

APPENDIX C: Strength Design Performance values in accordance with 2015 IBC

TRUBOLT+ AND *OVERHEAD* TRUBOLT+ WEDGE ANCHOR ALLOWABLE STRESS DESIGN (ASD) VALUES FOR ILLUSTRATIVE PURPOSES

Anchor Notation	Anchor Embedment Depth	Effective Embedment Depth	Allowable Tension Load
	(inches), h_{nom}	(inches), h_{ef}	(lbs)
3/8	2	1-5/8	1,090
1/2	2-1/2	2	1,490
	3-3/4	3-1/4	2,870
5/8	3-1/4	2-3/4	2,385
	4-3/4	4-1/4	3,910
3/4	4-3/8	3-3/4	3,825

For SI: 1 inch = 25.4 mm, 1 ft-lb = 4.45N.
Design Assumptions:
1 Single anchor with static shear load only.
[2] Load combinations from 2006 IBC, Sections 1605.2.1 and 1605.3.1 (no seismic loading).
[3] Thirty percent dead load and 70 percent live load, controlling load combination 1.2D + 1.6L
[4] Calculation of weighted average: 1.2D + 1.6L = 1.2 (0.3) + 1.6 (0.7) = 1.48
[5] Values do not include edge distance or spacing reductions.

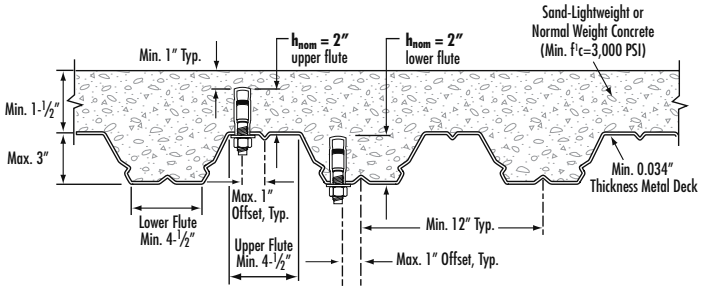
ITW RED HEAD TRUBOLT+ and *OVERHEAD* TRUBOLT+ WEDGE ANCHOR DESIGN INFORMATION FOR INSTALLATION IN THE SOFFIT OF CONCRETE FILL ON METAL DECK FLOOR AND ROOF ASSEMBLIES

TRUBOLT+ AND *OVERHEAD* TRUBOLT+ WEDGE ANCHOR DESIGN INFORMATION

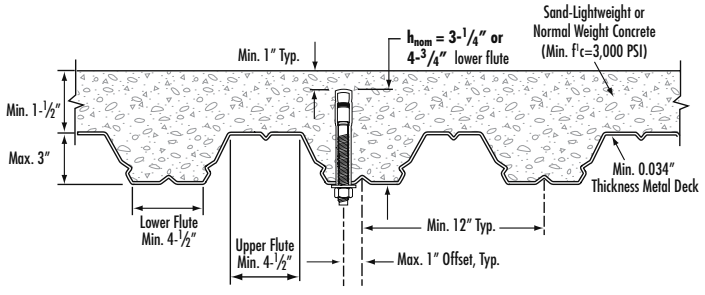
Characteristic	Symbol	Units	Nominal Anchor Diameter				
			3/8"	1/2"		5/8"	
			Upper /Lower	Upper /Lower	Lower Only	Lower Only	Lower Only
			h_{ef} = 1-5/8"	h_{ef} = 2"	h_{ef} = 3-1/4"	h_{ef} = 2-3/4"	h_{ef} = 4-1/4"
Pullout strength, uncracked concrete over metal deck	$N_{p, deck, uncr}$	lbf	2,170	2,515	5,285	3,365	6,005
Pullout strength, cracked concrete over metal deck	$N_{p, deck, cr}$	lbf	1,650	1,780	4,025	2,405	5,025
Reduction factor for pullout strength in tension, Condition B	ϕ	––	0.65				
Shear strength, uncracked concrete over metal deck	$V_{p, deck, uncr}$	lbf	1,640	2,200	3,790	2,890	6,560
Reduction factor for steel strength in shear	ϕ	––	0.60	0.65			
Anchor embedment depth	h_{nom}	in	2.0	2.5	3.75	3.25	4.75

For SI: 1 inch = 25.4 mm, 1 lbf = 4.45 N

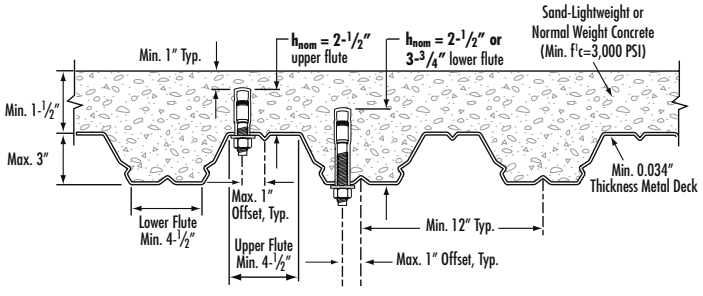
Nominal Anchor Diameter = 3/8″



Nominal Anchor Diameter = 5/8″



Nominal Anchor Diameter = 1/2″



APPENDIX C: Strength Design Performance values in accordance with 2015 IBC

ITW RED HEAD TRUBOLT+ WEDGE ANCHOR DESIGN INFORMATION TESTED TO ICC-ES AC 193 AND ACI 355.2, IN ACCORDANCE WITH 2015 IBC

TRUBOLT+ STAINLESS STEEL WEDGE ANCHOR DESIGN INFORMATION[1]

Trubolt+ Seismic Wedge Anchors

Characteristic	Symbol	Units	1/2"				5/8"	
Anchor category	1, 2 or 3	—	1				1	
Minimum effective embedment depth	h_{ef}	in	2		3-1/4		2-3/4	4-1/4
Minimum concrete member thickness	h_{min}	in	4	6	6	8	6	6-1/4
Critical edge distance	c_{ac}	in	6	6	7-1/2	6	7-1/2	6-1/2
Data for Steel Strengths – Tension and Shear								
Minimum specified yield strength	f_y	psi	65,000				65,000	
Minimum specified ultimate strength	f_{uta}	psi	100,000				100,000	
Effective tensile stress area (neck)	A_{se}	in^2	0.119				0.183	
Effective tensile stress area (thread)	A_{se}	in^2	0.142				0.217	
Steel strength in tension	N_{sa}	lbf	11,900				18,300	
Steel strength in shear, uncracked or cracked concrete [6]	V_{sa}	lbf	7,265				10,215	
Steel strength in shear – seismic loads	V_{eq}	lbf	5,805				8,105	
Strength reduction factor *f* for tension, steel failure modes [2]			0.75				0.75	
Strength reduction factor *f* for shear, steel failure modes [2]			0.65				0.65	
Data for Concrete Breakout Concrete Pryout Strengths in Tension and Shear								
Effectiveness factor – uncracked concrete	k_{uncr}	—	24				24	
Effectiveness factor – cracked concrete	k_{cr}	—	17				17	
Modification factor for cracked and uncracked concrete [3]	$y_{c,N}$	—	1.0				1.0	
Coefficient for pryout strength	k_{cp}	—	1.0		2.0		2.0	
Load-bearing length of anchor	l_e	in	2.0		3.25		2.75	4.25
Strength reduction factor f for tension, concrete failure modes, Condition B [2]			0.65				0.65	
Strength reduction factor f for shear, concrete failure modes, Condition B [2]			0.70				0.70	
Data for Pullout Strengths								
Pullout strength, uncracked concrete	$N_{p,uncr}$	lbf	See Footnote [4]		6,540		5,430	8,900
Pullout strength, cracked concrete	$N_{p,cr}$	lbf	See Footnote [4]				See Footnote [4]	
Pullout strength for seismic loads	N_{eq}	lbf	2,345		See Footnote [4]		See Footnote [4]	
Strength reduction factor *f* for tension, pullout failure modes, Condition B [2]			0.65				0.65	
Additional Anchor Data								
Axial stiffness in service load range in uncracked concrete	b_{uncr}	lbf/in	250,000				250,000	
Axial stiffness in service load range in cracked concrete	b_{cr}	lbf/in	20,000				20,000	

For SI: 1 inch = 25.4 mm, 1 in2 = 645.16mm2, 1 lbf = 4.45 N, 1 psi = 0.006895 MPa, 1 lbf • 102/in - 17,500 N/m.

[1] The 1/2" and 5/8" diameter Trubolt+ Wedge Anchors are ductile steel elements as defined by ACI 318 D.1.

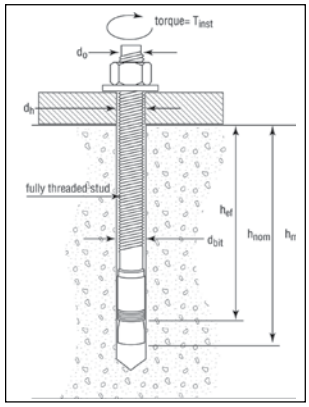
[2] All values of f apply to the load combinations of IBC Section 1605.2, ACI 318 Section 9.2 or UBC Section 1612.2. If the load combinations of Appendix C or UBC Section 1909.2 are used, the appropriate value of f must be determined in accordance with ACI 318 D.4.5. For installations where reinforcement that complies with ACI 318 Appendix D requirements for Condition A is present, the appropriate f factor must be determined in accordance with ACI 318 D.4.4.

[3] For all design cases $\Psi_{c,N} = 1.0$. The appropriate effectiveness factor for cracked concrete (k_{cr}) or uncracked concrete (k_{uncr}) must be used.

[4] Anchor pullout strength does not control anchor design. Determine steel and concrete capacity only.

[5] Steel strength in shear values are based on test results per ACI 355.2, Section 9.4 and must be used for design.

TRUBOLT+ WEDGE ANCHOR (INSTALLED)



TRUBOLT+ STAINLESS STEEL WEDGE INSTALLATION INFORMATION

Parameter	Notation	Units	1/2				5/8	
Anchor outer diameter	d_o	inches	0.5				0.615	
Nominal carbide bit diameter	d_{bit}	inches	1/2				5/8	
Effective embedment depth	h_{ef}	inches	2		3-1/4		2-3/4	4-1/4
Minimum anchor embedment depth	h_{nom}	inches	2-1/2		3-3/4		3-1/4	4-3/4
Minimum hole depth[1]	h_o	inches	2-3/4		4		3-1/2	5
Minimum concrete member thickness[1]	h_{min}	inches	4	6	6	8	6	6-1/4
Critical edge distance[1]	c_{ac}	In.	6	6	7-1/2	6	7-1/2	6-1/2
Minimum anchor spacing[1]	s_{min}	In.	6	5-3/4	4	5-3/4	8	6
Minimum edge distance[1]	c_{min}	In.	6				7-1/2	5
Minimum overall anchor length	l	inches	3-3/4		4-1/2		4-1/4	6
Installation torque	T_{inst}	ft-lb	45				90	
Minimum diameter of hole in fastened part	d_h	inches	5/8				3/4	

For SI: 1 inch = 25.4 mm, 1 ft-lb = 1.356 N-m.

APPENDIX D: Installation information for Tapcon+ Screw Anchors[1]

Characteristics	Symbols	Units	Nominal Anchor Diameter (inch)				
			1/4		3/8	1/2	
Head Style	-	-	Hex Head		Hex Head	Hex Head	
Nominal Outside diameter (Shank)	d_{a3}	in.	0.25		0.38	0.50	
Nominal Outside diameter (threads)	-	in.	0.33		0.46	0.59	
Drill Bit Specification	d_{bit}	in.	¼ Tapcon+ Bit	¼ Tapcon+ Bit	3/8 ANSI Bit	1/2 ANSI Bit	
Minimum base plate clearance hole diameter	d_h	in.	3/8		1/2	5/8	
Maximum installation torque[3]	Tinst, max	ft-lbf	20		50	70	
Maximum Impact Wrench Torque Rating	Timpact, max	ft-lbf	115		200	345	
Effective embedment depth	h_{ef}	in.	1.45		1.78	1.32	2.17	3.02
Minimum nominal embedment depth[4]	h_{nom}	in.	2		2 1/2	2	3	4
Minimum hole depth	h_{hole}	in.	2 1/4		2 3/4	2 1/4	3 1/4	4 1/4
Minimum concrete member thickness	h_{min}	in.	4		4	4	6	
Critical edge distance	c_{ac}	in.	2 1/2		4 1/2	3	4	5
Minimum edge distance	c_{min}	in.	1 1/2		1 1/2	2 1/2	1 3/4	2 1/2
Minimum Spacing	s_{min}	in.	3		3	3	3 1/2	3

APPENDIX D: Tension Strength Design Information for Tapcon+ Screw Anchors[1]

Table 2

Characteristic	Symbol	Units	Nominal Anchor Diameter (inch)					
			1/4		3/8	1/2		
Head Style	-	-	Hex Head		Hex Head	Hex Head		
Drill bit specification	-	in.	1/4 Tapcon+ Bit	1/4 ANSI Bit	3/8 ANSI Bit	1/2 ANSI Bit		
Anchor Category	1, 2, or 3	-	1	2	1	1		
Effective embedment depth	h_{ef}	in.	1.45		1.78	1.32	2.17	3.02
Minimum concrete member thickness	h_{min}	in.	4		4	4	6	
Critical edge distance	c_{ac}	in.	2 1/2		4 1/2	3	4	5
Data for Steel Strength in Tension								
Minimum specified yield strength	f_y	psi	100,000		100,000	100,000		
Minimum specified ultimate strength	$f_{uta}(f_{ut})$[5]	psi	125,000		125,000	125,000		
Effective tensile stress area	A_{se}	in^2	0.0470		0.098	0.1850		
Steel strength in tension	V_{sa}	lbf	5,900		12,250	23,125		
Strength reduction factor Φ for tension, steel failure modes[2]	Φ_{sa}	-	0.65		0.65	0.65		
Data for Concrete Breakout Strength in Tension								
Effectiveness factor - uncracked concrete	k_{uncr}	-	24		27	30		
Effectiveness factor - cracked concrete	k_{cr}	-	17		17	17		
Modification factor for cracked and uncracked concrete[3]	$\Psi_{c,N}$ (Ψ_3)[5]	-	1.0		1.0	1.0		
Strength reduction factor Φ for tension, concrete failure modes, Condition B[3]	Φ_{cb}	-	0.65	0.55	0.65	0.65		
Data for Pullout Strength in Tension								
Pullout strength, uncracked concrete	$N_{p,uncr}$	lbf	2,107		See footbote 4	See footnote 4		
Pullout strength, cracked concrete	$N_{p,cr}$	lbf	857		1,837	See footnote 4		
Pullout strength for seismic loads	$N_{p,eq}$	lbf	857		1,677	See footnote 4		
Strength reduction factor Φ for tension, pullout failure modes, Condition B[3]	Φ_p	-	0.65	0.55	0.65	See footnote 4		
Additional Anchor Data								
Axial stiffness in service load range in uncracked concrete	β_{uncr}	lbf/in	385,000		800,000	800,000		
Axial stiffness in service load range in cracked concrete	β_{cr}	lbf/in	225,000		365,000	365,000		

For SI: 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m

[1] The data presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D

[2] The tabulated value of Φ_{sa} applies when the load combinations of Section 1605.2.1 of the IBC or ACI 318 section 9.2 are used. If load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4(b).

[3] The tabulated value of Φ_{cb} and Φ_{cp} applies when the load coombinations of Section o1605.2.1 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4(c) for Condition B

[4] Pullout resistance does not govern design and does not need to be considered

[5] The notation in parenteses is for the 2006 IBC

[6] For calculation only. For actual h_{ef} see Table 1

[7] For the strength between the threaded cap and anchor head

APPENDIX D: Shear Strength Design Information for Tapcon+ Screw Anchors[1]

Table 3

Characteristic	Symbol	Units	Nominal Anchor Diameter (inch)						
			1/4		3/8	1/2			
Head Style	-	-	Hex Head		Hex Head	Hex Head			
Drill bit specification	-	in.	1/4 Tapcon+ Bit	1/4 ANSI Bit	3/8 ANSI Bit	1/2 ANSI Bit			
Anchor Category	1, 2, or 3	-	1	2	1	1			
Minimum effective embedment depth	h_{ef}	in.	1.45		1.78	1.32	2.17	3.02	
Minimum concrete member thickness	h_{min}	in.	4		4	4	6		
Critical edge distance	c_{ac}	in.	2 1/2		4 1/2	3	4	5	
Data for Steel Strengths in Shear									
Minimum specified yield strength	f_y	psi	100,000		100,000	100,000			
Minimum specified ultimate strength	$f_{uta}(f_{ut})^5$	psi	125,000		125,000	125,000			
Effective shear stress area	A_{se}	in^2	0.0470		0.098	0.1850			
Steel strength in shear - static	V_{sa}	lbf	2,045		3,621	12,610			
Steel strength in shear - seismic	$V_{sa, eq}$	-	1,350		2,920	9,300			
Strength reduction factor Φ for shear, steel failure modes[2]	Φ_{sa}	-	0.60		0.60	0.60			
Data for Concrete Breakout and Concrete Pryout Strengths in Shear									
Nominal Outside Diameter (shank)	$d_a(d_o)^4$	in.	0.25		0.38	0.50			
Load bearing length of anchor	ℓ_e	-	1.45		1.78	1.32	2.17	3.02	
Coefficient for pryout strength	κ_{cp}	-	1.0		1.0	1.0		2.0	
Strength reduction factor for shear, concrete breakout[3]	Φ_{cb}	-	0.70		0.70	0.70			
Strength reduction factor for shear, pryout[3]	Φ_{cp}	-	0.70		0.70	0.70			

For SI: 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m

[1]The data presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D

[2] The tabulated value of Φ_{sa} applies when the load combinations of Section 1605.2.1 of the IBC or ACI 318 section 9.2 are used. If load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4(b).

[3] The tabulated value of Φ_{cb} and Φ_{cp} applies when the load coombinations of Section o1605.2.1 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318-11 D.4.3(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4(c) for Condition B

[4] Pullout resistance does not govern design and does not need to be considered

[5] The notation in parenteses is for the 2006 IBC

[6] For calculation only. For actual h_{ef} see Table 1

[7] For the strength between the threaded cap and anchor head

APPENDIX D: Tapcon+ Screw Anchors Design Information for Anchors Located in the Soffit of Concrete Over Steel Deck Floor and Roof Assemblies[1,2,3,4,5]

Characteristic	Symbol	Units	Nominal Anchor Diameter (inch)		
			1/2		
Location of installation	-	-	Lower Flute		Upper Flute
Minimum hole depth	h_{hole}	in.	2 1/2	4 1/2	2 1/2
Nominal embedment depth	h_{nom}	in.	2	4	2
Minimum effective embedment depth	h_{ef}	in.	1.32	3.02	1.32
Characteristic pullout strength, uncracked concrete over metal deck	$N_{p,\ deck,uncr}$	lbf	1,720	4,950	2,405
Characteristic pullout strength, cracked concrete over metal deck	$N_{p,\ deck,cr}$	lbf	975	2,805	1,360
Characteristic shear strength, concrete over metal deck	$V_{sa,\ deck}$	lbf	3,825	6,130	3,825
Characteristic shear strength - seismic, concrete over metal deck	$V_{sa,\ deck,\ eq}$	lbf	2,820	4,520	2,820
Reduction factor for pullout strength in tension, Condition B	Φ	-	0.65		
Reduction factor for pullout strength in shear, Condition B	Φ	-	0.65		

For SI: 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m

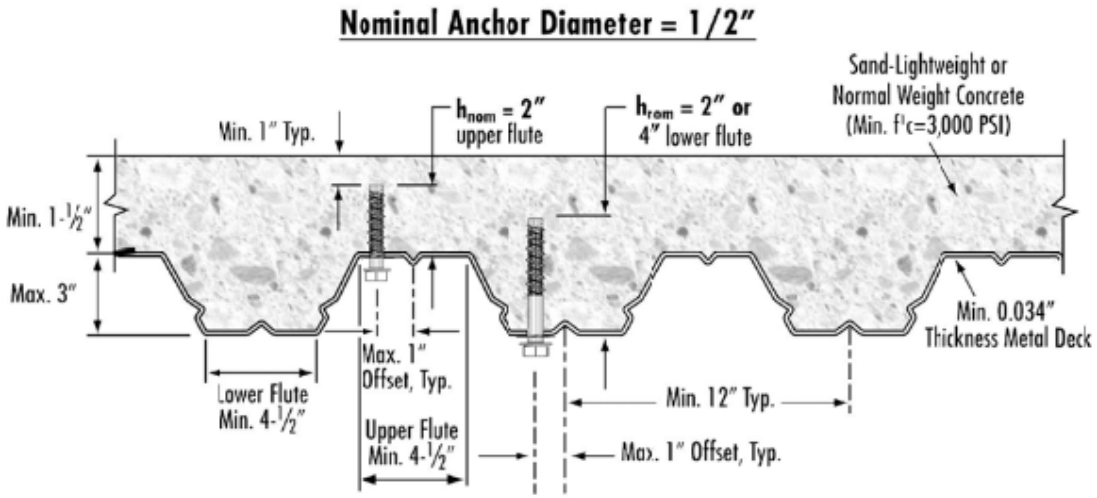
[1]Values for $N_{p,\ deck,uncr}$, $N_{p,\ deck,cr}$, $V_{sa,\ deck}$, $V_{sa,\ deck,\ eq}$ apply to sand-lightweight concrete having a inimum concrete compressive strength, f'_c of 3,000 psi.

[2] The characteristic pull-out strength for greater concrete compressive strengths shall be increased by multiplying the tabular value by $(f'_c / 3000psi)^{0.5}$

[3] All values of Φ apply to the load combinations of IBC Section 1605.2.1, or ACI 318 Section 9.2. If the load combinations of Appendix C are used, then appropriate value of Φ must be determined in accordance with ACI 318-11 D.4.4. For installations where reinforement that complies with ACI 318 Appendix D requirements for Condition A is present, the appropriate Φ factor must be determined in accordance with ACI 318-11 D.4.3.

[4] The minimum anchor spacing along the flute must be greater of 3 h_{ef} or 1.5 times the flute width in accordance with Section 4.1.11 of this report

[5] Installation must comply with Figure 6 of this report



Notes